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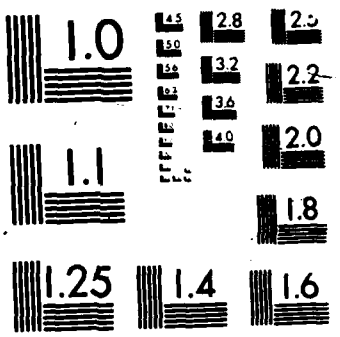
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In this grant funds were requested and received for the purchase of an epitaxial growth and analysis apparatus to investigate the chemistry, photochemistry, and kinetics of growth of semiconductor thin films by metalorganic chemical vapor deposition (MOCVD). The apparatus consists of an epitaxial growth chamber compatible with the inclusion of in situ diagnostic techniques, an excimer-dye laser system for use in laser induced flourescence (LIF) studies of gaseous speecies, and a mass spectrometer for in situ analysis of gaseous constituents of MOCVD growth environment. These items were to be incorporated into a system for the investigation of the growth kinetics of MOCVD.

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FINAL REPORT

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INTRODUCTION

In this grant funds were requested and received for the purchase of an epitaxial growth and analysis apparatus to investigate the chemistry, photochemistry, and kinetics of growth of semiconductor thin films by metalorganic chemical vapor deposition (MOCVD). The apparatus consists of an epitaxial growth chamber compatible with the inclusion of *in situ* diagnostic techniques, an excimer-dye laser system for use in laser induced flourescence (LIF) studies of gaseous speecies, and a mass spectrometer for *in situ* analysis of gaseous constituents of MOCVD growth environment. These items were to be incorporated into a system for the investigation of the growth kinetics of MOCVD.

EQUIPMENT PURCHASED

The equipment purchased on this grant is listed below.

1.) Epitaxial Growth Chamber consisting of :	
a) CVD Equipment Corporation Reactor Cabinet	$10650
b) Ircon Model 6000 Infrared Thermometer	$ 3285
2) Laser Induced Flourescence System consisting of :	
a) Questek UV Excimer Laser	$33034
b) Lumonics EPD-330 Dye Laser	$11432
c) RCA 31034 Photomultiplier Tube	$ 1540
d) Stanford Research Boxcar Integrator	$10165
e) Products for Research Photomultiplier Housing	$ 3376
3) Mass Spectrometer Sytem consisting of :	
a) UTI Model 100C-02 Mass Spectrometer	$19207
b) IBM PC-XT computer	$ 3930
c) IBM Math Coprocessor	$ 876
d) Sysgen Image Unit Controller	$ 2806
e) IEEE-488 Interface Card	$ 420
f) Tekmar Lab Master Card	$ 1371
g) Sorption Pump*	$ 1485
h) Turbomolecular Pump*	$ 8307
i) Stainless Steel Flexible Hose*	$ 1670
j) Ionization Guage*	$ 310

*These items funded by USC cost share.

The epitaxial growth cabinet and thermometer are now in use in conjunction with a gas handling system purchased from CVD Equipment for the growth of a variety of semiconductor structures. The cabinet houses two reaction chambers for MOCVD growth and virtually all growth experiments occuring our laboratory take place in these chambers. The original plan of incoporating the *in situ* measurements in the same cabinet has been abandoned owing to lack of space and reactor time. A separate laboratory has been established for this purpose and a small gas distribution system is being assembled for these studies. The laser induced flourescence system is in place and has been tested in parts to establish working order. The mass spectrometer system is designed to be a multiple stage differentially pumped system to allow sampling of gas mixtures near atmospheric pressure. We have designed this system and are currently assembling it using the purchased items and parts from an abandoned ion implanter. This apparatus as well as the LIF system are to be housed in the Reaction Kinetics Laboratory we are establishing. A schematic diagram of the laboratory is shown below.

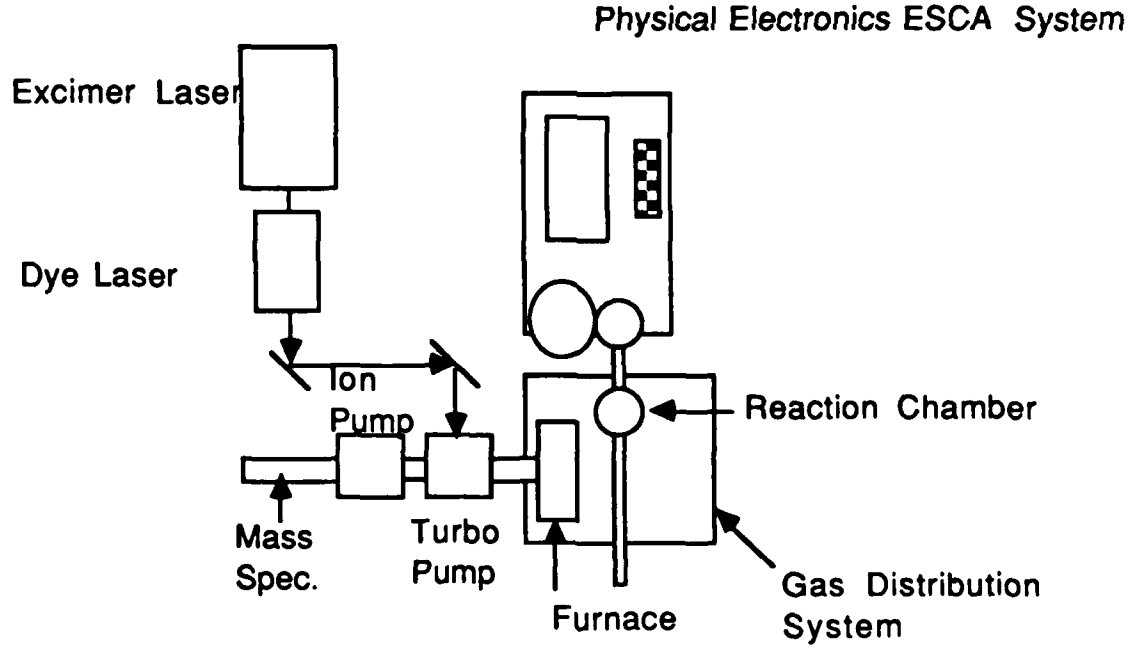

Figure 1
MOCVD Kinetics laboratory layout showing positioning of equipment obtained on this grant.

RESEARCH PROJECTS

The equipment listed above has been used in part for several programs and there are ongoing programs that rely on the availability of this apparatus for their successful completion. We describe below the variuos programs for which this apparatus is in use and for which we expect it to be useful.

Growth Kinetics of In-containing III-V Semiconductors by MOCVD
Naval Research Laboratory Contract No. N00014-84-C-2254

The goal of this program is to develop a better understanding of the kinetics of growth and interface formation involved in the growth of InGaAs on InP substrates by MOCVD. Thus the program involves the study of the chemical and physical kinetics involved in the growth of InGaAs on InP. The initial phases of the program requires the determination of the rates of thermal decomposition of trimethylgallium (TMGa), AsH_3, TMIn, and PH_3. The effects of substrate surfaces on the decomposition of these reactants as well as the role of reactor wall deposits are also of importance. Later stages of the program will focus on analysis of the transient species in the reactor during growth and interface formation using mass spectroscopy and LIF. This is of particular relevance to the study of the formation of heterointerfaces involving different column V elements. The final stages of the program are devoted to the study of the active surface species involved in the interface formation using XPS techniques on an apparatus containing an integral growth chamber. This apparatus will also have optical access so that the excimer and dye laser can be used to modify the surface kinetics.

Atomic Layer Epitaxy
Office of Naval Research Contract No. N00014-84-K-0331

The object of this program is to study the growth of GaAs by the deposition of alternate monolayers of Ga and As. We are attempting to accomplish this by several means. The primary two approaches however involve the thermal and/or photodecomposition of TMGa and AsH_3 on GaAs surfaces. In the former case the surface is exposed alternately to gas mixtures containing only TMGa or AsH_3 at an appropriate temperature to effect the decomposition of the reactants.

The surface dosage of Ga is controlled either by time and flow rate or by employing carrier gas mixtures which impede the gas phase decomposition of the reactant. The photo assisted ALE is accomplished by dosing the surface with TMGa or AsH_3 under UV or visible illumination at a temperature well below that required for thermal decomposition of the TMGa or AsH_3. The apparatus obtained on this URIP was instrumental in determining the role of surface catalysis in the decomposition of AsH_3. Further studies will include the preparation of surface reactive intermediate species in the gas phase by photoexcitation with the UV or visible laser.

Heterojunction Materials and Devices Grown by Metalorganic Chemical Vapor Deposition, USC Joint Services Electronics Program, Project SS-1
Contract No. F49620-85-C-0071

The purpose of this program is to develop techniques for the growth and fabricvation of heterojunction devices by MOCVD in the AlGaAs and InGaAsP materials systems. The major focus of these efforts is the formation of high quality interfaces that will allow the fabrication of high quality quantum well lasers, heterojunction bipolar transistors, and HEMT devices. An integral portion of this work is to determine the effect of processing on the abruptness of interfaces. To this end we have explored the effects of impurity diffusion on the stability of MOCVD grown interfaces. We have characterized the effect of Zn diffusion on the interdiffusion of Al and Ga at interfaces and will attempt to assess the role of transient heating on the stability of the interfaces by the use of the localized heating with the excimer laser.
We are also exploring the use of the excimer laser as a processing tool to induce localized disordering with the goal of creating synthetic materials structures and device designs by patterning the quantum well regions.

Low Temperature Processes For High Efficiency Solar Cells
Solar Energy Research Institute
Subcontract No. XB-5-05009-3

The purpose of this program is to develop a first order model of MOCVD growth mechanisms by utilizing the known and measured rates of decomposition of organometallics and hydrides in an atmosphere appropriate to MOCVD growth. The rates of

decomposition of the compounds in the presence of optical excitation will also be assessed using the apparatus purchased on this URIP grant with the goal of developing a photo-assisted MOCVD process that will permit the fabrication of device structures at low growth temperatures. The mass spectrometer system, excimer/dye laser system and reactor cabinet will all be employed in various phases of this program. The mass spectrometer will be employed to determine the rates of decomposition of the various stages of organometallic molecules and the product species of photo-decomposition. The laser system will be used as a tunable excitation source for the studies of photodecomposition and will be used as a source for the development of a photo-assisted MOCVD process.

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